Microcell Channel Models for Multi-Hop Relaying (2GHz & 5GHz)

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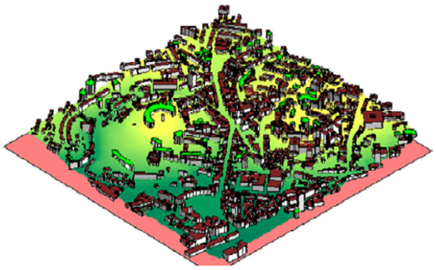
- Work performed in the ROMANTIK project is presented that provides an statistical analysis of peer-to-peer radio channels in an urban micro-cellular environment.
- The work focuses on the 2.1GHz (UMTS) and 5.2GHz (Hiperlan/2 and 802.11a/e) bands and makes use of a detailed three-dimensional ray-tracing tool. Existing models are inappropriate for low mounted transmitters such as those used in multi-hop communications at interested frequency band
- Propagation analysis reveals that the standard deviation of the shadowing and the rms delay spread are a function of the separation distance between the transmitter and receiver.
- Path loss is seen to increase with lower terminal heights, as is the probability of line-of-sight.

- a statistical channel model for low mounted (relative to ground height) wireless links in urban environments is presented. Channel properties such as *Path Loss*, *Shadowing Standard Deviation*; *Delay Spread* (DS) and *Azimuth Angular Spread* (AS) are considered for BS-MS, BS-RN, RN-MS, RN-RN and MS-MS links.

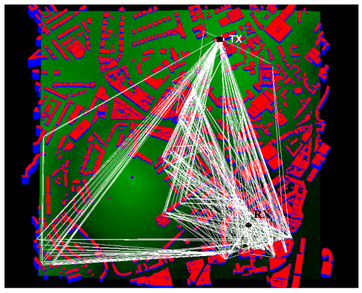
Radio Environment	Microcell, Urban
Typical building height	12 m
Base Station (BS) height	15 m (at roof-top level)
Relay node (RN) height	5 m (under roof-top)
Mobile Station (MS) height	1.5 m
Carrier frequency	2.1/5.2 GHz

Multi-Hop Models for Urban Environment

- A 3D Ray Tracing model previously that developed and validated at the University of Bristol is used to the predict power as well as time, frequency and spatial dispersion in the radio channel.
- Simulations are based on a 1.4km x 1.4km map database (terrain, building, foliage and ground cover data) of central Bristol. The urban environment is typical of a European city.
- 26 different transmitter sites were used. a total of 9,003 x 26 channel data are generated for each of the BS-MS, BS-RN, RN-RN, RN-MS and MS-MS link.

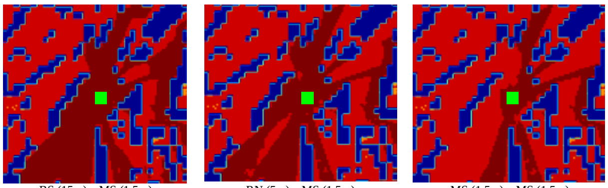


3-D Database of Bristol (1km by 1km)



Ray tracing Model Output

LOS and NLOS – A Key Concept

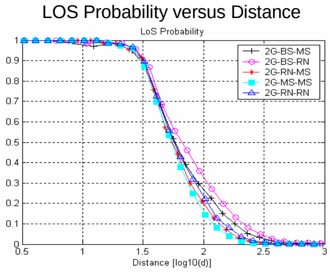


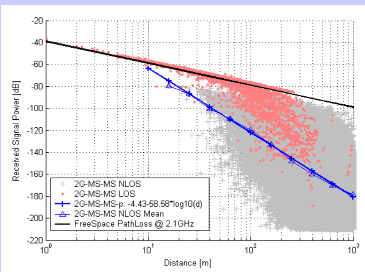
BS (15m) – MS (1.5m) RN (5m) – MS (1.5m) MS (1.5m) – MS (1.5m)

LOS NLOS Building Tx

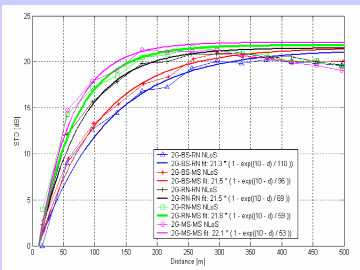
- For low mounted transmitters the probability of LOS falls off quickly with distance and this is critical to the radio channel
- Path Loss parameters and other channel characters, e.g. DS and AS, depend on whether the location is LOS or NLOS – this probability is distance dependent

LOS Probability versus Distance

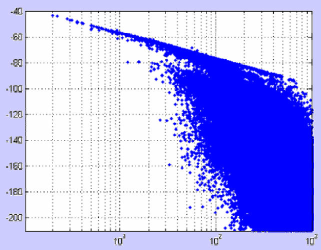




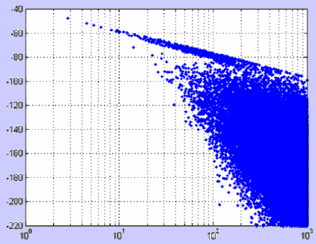
Scatter plot of the received power versus Distance



The shadowing standard deviation is distance dependent



MS-MS from Ray Model



MS-MS from Statistical Model

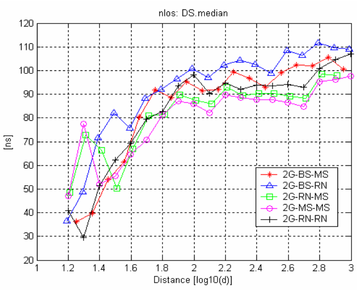
$$L(dB) = b + 10n \log_{10}(d/d_0)$$

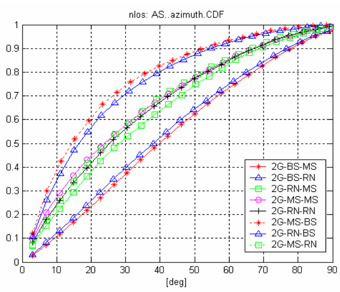
NLOS	2G		5G	
	b (dB)	*n*	*b (dB)*	*n*
BS-RN	16.29	4.64	26.73	4.92
BS-MS	13.07	4.88	24.13	5.14
RN-RN	8.96	5.42	25.61	5.44
RN-MS	10.04	5.47	27.54	5.48
MS-MS	4.43	5.86	23.1	5.82

- In NLOS conditions, shadowing can be characterized by a lognormal distribution (a normal distribution in dB)
- The shadowing standard deviation tends to increase as the distance increase
- The distant dependent shadowing various could be modeled using following function:

$$STD(d) = S \cdot (1 - e^{-(d-d_0)/n_s})$$

- Distance dependent LOS and shadowing variance provides the basis for an accurate multi-hop path loss model





- The RMS DS is seen to increase with increasing separation distance for both LOS and NLOS, particularly for short distance TX and RX separation.
- And higher antenna elevations result in higher RMS DS
- The median RMS AS remains similar for all distance separations.
- It has been found that the median RMS AS for LOS conditions is much smaller than the NLOS cases, and the higher frequency has lower RMS AS values.